

INDOOR AIR QUALITY ASSESSMENT

**Uxbridge High School
62 Capron Street
Uxbridge, Massachusetts 01569**



Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Daniel J Stefanilo, Superintendent, and Tim Rice, Health Agent, the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality at Uxbridge High School, 62 Capron Street, Uxbridge, Massachusetts. This request was made to identify possible indoor air quality issues at the school.

On May 25, 2005, a visit was made to this school by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), CEH, to conduct an indoor air quality assessment. The original school is a two-story brick structure with a basement built in 1938. An addition was added in 1988. The school contains general classrooms, science rooms, art room, gymnasium, auditorium, print shop, music room, media center, cafeteria and office space. A classroom located in the basement is used to house pre-school students.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

This school has a student population of approximately 520 and a staff of approximately 60. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million parts (ppm) in air in nine of fifty-two areas surveyed, indicating adequate ventilation in the majority of areas surveyed. It should be noted that several classrooms were sparsely populated or had open windows during the assessment, which can greatly reduce carbon dioxide levels.

Fresh air in classrooms is supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit ([Figure 1](#)). Fresh air and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Univents were found deactivated in some classrooms. Obstructions to airflow, such as objects stored on or in front of univents, were also observed in a number of classrooms (Picture 1). In order for univents to function as designed, univents must be activated and remain free of obstructions.

The mechanical exhaust ventilation system consists of wall-mounted exhaust vents, some of which are located in ungrated holes at floor level (Picture 2). These vents are connected to exhaust fans on the roof. Filing cabinets and other items obstructed a number of exhaust vents.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while

removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat

irritation, lethargy and headaches. For more information concerning carbon dioxide, see [Appendix A](#).

Temperature measurements ranged from 70° F to 75° F, which were within the MDPH recommended comfort range. The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 35 to 47 percent, which is within or close to the lower end of the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A number of interior areas of the building had signs of water damage in ceiling tiles. While some classrooms appear to have experienced leaks through window frames, the library had a large number of water damaged ceiling tiles. As reported by Michael Legenedre, Uxbridge Schools Plant Manager, flashing is missing between the roof and exterior wall of the library (Pictures 3 and 3A). This condition has led to both wind-driven rain and snow to penetrate under certain wind conditions. The integrity of the building envelope (e.g., roof, exterior walls, foundation, window and doorframes) must

be constructed in a manner to prevent water intrusion. If ceiling tiles become wet repeatedly they can provide a medium for mold growth. The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur.

Of note was termite damage and water damage to windowsills and wood molding located in the basement of the original building (Picture 4). Wood boring insects tend to attack soft, moist wood. The termite infestation is a sign that water is likely penetrating through the foundation. Shrubbery was observed growing in close proximity to the foundation (Pictures 5 and 6). Roots growing against the exterior walls can bring moisture in contact with walls and eventually lead to cracks and/or fissures in the foundation below ground level. Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

The science wing contains a greenhouse (Pictures 7 and 8). The greenhouse does not have a local exhaust fan to vent water vapor, excess heat, particles and odors associated with horticulture out of the building. Without an exhaust vent, particulates and odors from the greenhouse can migrate into adjacent areas via the hallway door.

Other Concerns

Several other conditions were noted during the assessment that can affect indoor air quality. Room 007 contains a wet ink printing press (Picture 9). No local exhaust ventilation exists for the printer. Inks, washes and hand cleaners used in printing can

contain volatile organic compounds (VOCs), which can be irritating to the eyes, nose, throat and respiratory system. Products containing VOCs should be used with adequate exhaust ventilation to prevent exposure.

A number of classrooms contained upholstered furniture. Upholstered furniture is covered with fabric that comes in contact with human skin. This type of contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. In addition, if relative humidity levels increase above 60 percent, dust mites tend to proliferate (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, M.A., 1994). It is also recommended that upholstered furniture (if present in schools) be professionally cleaned on an annual basis or every six months if dusty conditions exist outdoors (IICRC, 2000).

Also of note was the amount of materials stored inside classrooms. Items were seen piled on windowsills, tabletops, counters, bookcases and desks in classrooms throughout the school. The large amount of items stored allows for dusts and dirt to accumulate. These stored items, (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Dirt and dust accumulation was also noted in the interiors of univents. When activated, this material can become aerosolized by the univents. Dust can be irritating to the eyes, nose and respiratory tract.

Conclusions/Recommendations

In view of the findings at the time of this visit, the following recommendations are made:

1. Examine the feasibility of reestablishing the integrity of the building envelope by installing flashing for the library roof.
2. Examine the feasibility of providing local exhaust vents for the printing press. If not feasible move the printing press to an area with an exterior wall where exhaust ventilation can be readily installed or already exists.
3. Replace water damaged ceiling tiles.
4. Consider installing an exhaust fan in the window of the greenhouse.
5. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
6. Operate all ventilation systems that are operable throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control to maximize air exchange.
7. Remove all blockages from univents and exhaust vents to ensure adequate airflow. Shut classroom doors to facilitate air exchange.
8. Change filters for air handling equipment as per the manufacture's recommendations or more frequently if needed. Clean out interiors of univents regularly (e.g., during scheduled filter changes).
9. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high

- efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
10. Clean upholstered furniture on the schedule recommended in this report. If not possible/practical, remove upholstered furniture from classrooms.
 11. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
 12. Consider the following actions to prevent moisture penetration into the basement/crawlspace:
 - a) Remove foliage to no less than five feet from the foundation.
 - b) Improve the grading of the ground away from the foundation at a rate of 6 inches per every 10 feet (Lstiburek & Brennan, 2001).
 - c) Install a water impermeable layer on ground surface (clay cap) to prevent water saturation of ground near foundation (Lstiburek & Brennan, 2001).
 13. Consider adopting the US EPA (2000b) document, *Tools for Schools*, in order to provide self-assessment and maintain a good indoor air quality environment. The document can be downloaded from the Internet at <http://www.epa.gov/iaq/schools/index.html>.
 14. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings.

Copies of these materials are located on the MDPH's website:

http://mass.gov/dph/indoor_air.

References

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Picture 1



Univent behind Desk

Picture 2



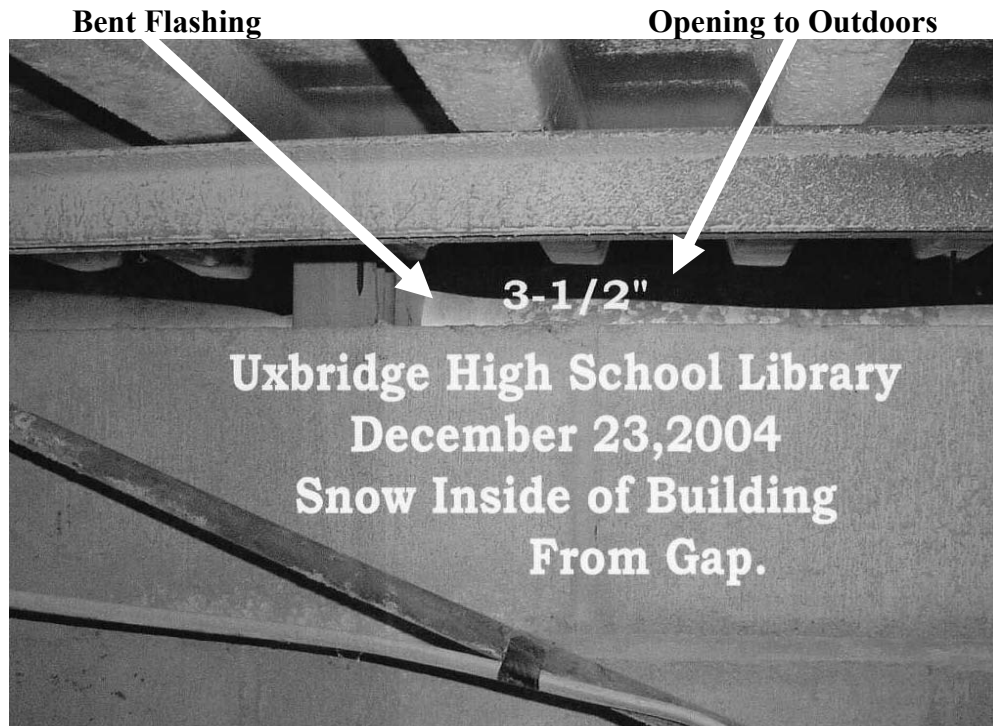
Example of Exhaust Vent, Note its Location behind Hallway Door

Picture 3



Exterior View of Roof/Exterior Wall Joint of Library

Picture 3A



Interior View of Space between Wall and Roof Decking
(Photo Taken By Michael Legendre, Uxbridge Public Schools)

Picture 4



Termite Damage to Wood in Basement Classrooms

Picture 5



Shrubbery outside Classrooms with Termite Damage

Picture 6



View of Shrubberty from Inside Classroom with Termite Damage

Picture 7



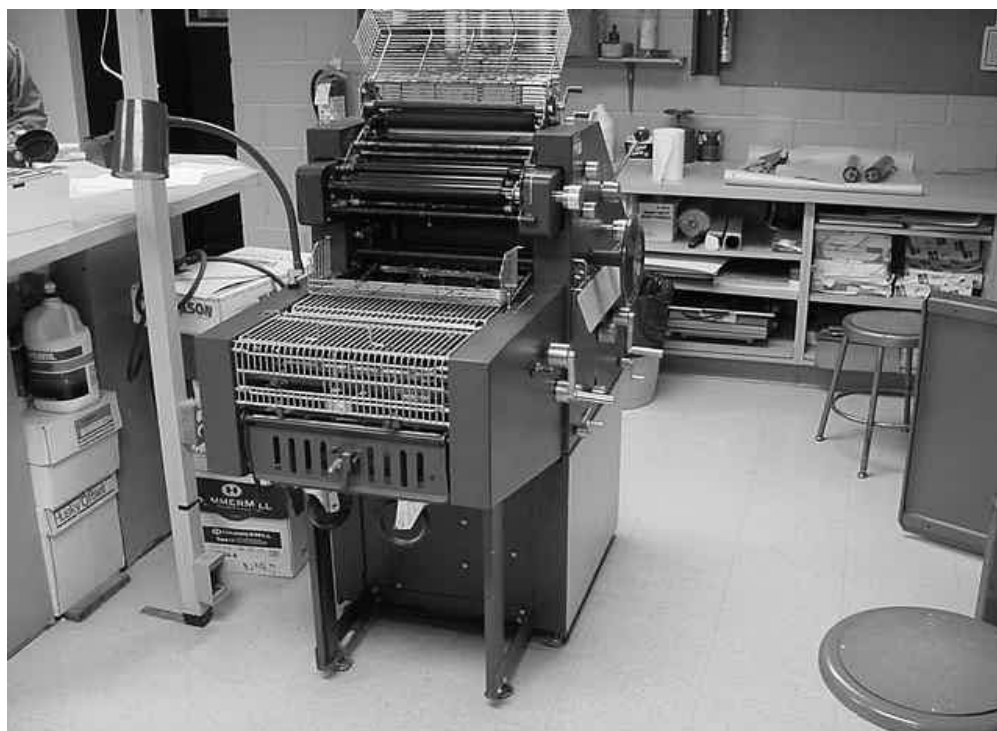
View of Greenhouse from Hallway

Picture 8



Exterior View of Greenhouse

Picture 9



Wet Ink Printing Press

TABLE 1
Indoor Air Test Results
Uxbridge High School, Uxbridge, MA
May 25, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outside (Background)	348	53	46					
204	526	70	46	0	N	Y	Y	Chemical hood
209	533	72	44	0	Y	Y	Y	
210	521	72	40	0	Y	Y	Y	
211	510	71	39	0	Y	Y	Y	
212 Greenhouse	663	72	47	0	N	N	N	No exhaust vent Door open
213	531	72	39	1	Y	Y	Y	1 missing ceiling tile Door open
214	481	72	37	0	Y	Y	Y	4 water damaged ceiling tiles
205	538	72	35	7	Y	Y	Y	Door open
203	379	73	35	0	Y	Y	Y	Exhaust blocked by cabinet

* ppm = parts per million parts of air

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

Table 1-1

TABLE 1
Indoor Air Test Results
Uxbridge High School, Uxbridge, MA
May 25, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
223	485	72	37	0	Y	Y	Y	
224	462	73	36	0	Y	Y	Y	Door open
225	766	72	37	10	Y	Y	Y	5 water damaged ceiling tiles
226	534	72	36	0	Y	Y	N	
227	582	73	36	7	N	Y	Y	10 water damaged ceiling tiles
231 Library	556	70	36	7	Y	Y	Y	20+ water damaged ceiling tiles 18 Computers
233 Computer room	573	71	37	5	N	Y	Y	8 water damaged ceiling tiles Door open
234	1213	73	43	16	N	Y	Y	Door open
237	550	73	43	16	N	Y	Y	
238	570	73	36	2	Y	Y	Y	Exhaust vent blocked with boxes

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Table 1-2

TABLE 1
Indoor Air Test Results
Uxbridge High School, Uxbridge, MA
May 25, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
202	1002	72	39	11	Y	Y	Y	Supply off Door open
206	577	71	36	15	Y	Y	Y	Exhaust blocked with desk Door open
207	936	73	39	16	N	Y	Y	
218	1241	73	39	17	Y	Y	Y	
219	628	74	36	0	Y	Y	Y	Supply off Supply blocked with desk Desk in air stream of univent Exhaust behind door
220	1037	74	38	13	Y	Y	Y	Upholstered furniture
221	788	72	37	6	Y	Y	Y	Water damaged plaster Window open Supply off
222	1299	72	42	0	Y	Y	Y	Supply off

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Table 1-3

TABLE 1
Indoor Air Test Results
Uxbridge High School, Uxbridge, MA
May 25, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
235	1318	74	42	23	Y	N	N	1 water damaged ceiling tile
Weight room	644	73	38	0	Y	M	M	1 water damaged ceiling tile
131	791	73	40	5	Y	Y	Y	
130	748	73	38	14	Y	Y	Y	4 water damaged ceiling tiles
129	781	70	42	0	Y	Y	Y	6 water damaged ceiling tiles 1 missing ceiling tile
128	741	70	42	6	Y	Y	Y	Supply off Cluttered Upholstered furniture Door open
127	1178	71	43	14	Y	Y	N	Door open
126	617	70	40	1				Exhaust vent could not be located Door open
125	634	71	40	11	N	Y	Y	3 water damaged ceiling tiles

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Comfort Guidelines

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Table 1-4

TABLE 1
Indoor Air Test Results
Uxbridge High School, Uxbridge, MA
May 25, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
117	981	73	39	10	N	Y	Y	
116	814	74	38	11	N	Y	Y	19 computers door open
115	467	72	35	1	N	Y	Y	Door open
117 Main office	625	72	38	4	N	Y	Y	
112	760	72	38	4	N	Y	Y	1 water damaged ceiling tile
103	582	71	37	5	Y	Y	Y	
Auditorium	537	73	39	4	Y	Y	Y	
Teacher's Lounge	585	74	39	3	N	N	Y	3 water damaged ceiling tiles upholstered furniture door open
Cafeteria	721	73	42	5	Y	Y	Y	5 water damaged ceiling tiles

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Comfort Guidelines

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Table 1-5

TABLE 1
Indoor Air Test Results
Uxbridge High School, Uxbridge, MA
May 25, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
006 Family/Consumer Science	695	75	37	12	Y	Y	Y	Termite damage Door open
007	409	71	36	1	Y	Y	Y	Wet ink printing press
005	669	73	38	2	Y	Y	Y	
004	463	71	38	1	Y	Y	Y	Termite damage
Art Room	506	71	37	7	Y	Y	Y	Door open
002	694	74	39	7	Y	Y	Y	
003	748	74	38	15	Y	Y	Y	

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Table 1-6